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# A COMPARATIVE STUDY OF DUSTING BY MEANS OF AIRPLANE AND GROUND MACHINE FOR THE CONTROL OF THE BLUEBERRY MAGGOT

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## INTRODUCTION

During the summer of 1925, the Bureau of Entomology undertook an investigation of the blueberry maggot (*Rhagoletis pomonella* Walsh) in Washington County, Me. The successful results obtained during recent years by a number of workers (Severin[2] in Maine, Brittain and Good[3] in Nova Scotia, Porter[4] in Connecticut, and others elsewhere) in the use of arsenical applications in combating this insect as an apple pest immediately suggested the use of similar treatments for its control when infesting the blueberry.

As even a cursory study of the blueberry lands of eastern Maine indicates, however, that large-scale applications of liquid spray on these lands would be impracticable, the work along the line of artificial control was confined to applications of arsenical dusts.

Preliminary experiments during the summer of 1925 demonstrated that the blueberry plants are rather resistant to injury from calcium arsenate and lead arsenate when these are applied in dust form.

During the season of 1926 six plots, with a total area of 15.39 acres, were dusted with calcium arsenate or with lead arsenate. Four applications of dust were made on three plots, and three applications were made on the other plots. Crank-type hand dust guns were used for this work.

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[1] B. J. Rudquist, R. R. Whitten, and C. W. Lacaillade, jr., field assistants in the Bureau of Entomology during the summer of 1928, rendered valuable aid in the work reported upon in this circular. The writers also take occasion to express their appreciation to H. D. Fallon, F. W. Pierce, jr., and Jerome Strout, engineers of the U. S. Bureau of Public Roads, for their cooperation in surveying the plots to be dusted, and to W. C. Hammond, who piloted the plane, and Lester Flewellin, the mechanic, for their excellent work which was done under rather unfavorable conditions.

[2] Severin, H. H. P. soluble poisons in the poisoned bait spray to control the adult of the apple maggot (rhagoletis pomonella walsh). Me. Agr. Expt. Sta. Bul. 251, p. [149]-168, illus. 1916.

[3] Brittain, W. H., and Good, C. A. the apple maggot in nova scotia. Nova Scotia Dept. Agr. Bul. 9, 70 p., illus. 1917.

[4] Porter, B. A. the apple maggot. U. S. Dept. Agr. Tech. Bul. 66, 48 p., illus. 1928.

The application of dust to the blueberry land in 1926 proved much more practicable than had been anticipated, and the reduction of maggot infestation resulting from the treatments was very satisfactory.

With this encouragement, the work was carried forward in a larger way during the summer of 1927. This season five plots, with a total area of 58.31 acres, were dusted by means of a large orchard duster mounted on a heavy farm wagon. A more detailed knowledge of the life history of the maggot, resulting from investigations of the previous summer, permitted more intelligent timing of the dusting schedule, which resulted in a reduction in the number of the applications of dust from four to two.

Treatments applied during the summer of 1927 were again successful in combating the maggot, and the methods employed proved thoroughly practical.

The results of the experiments conducted during the preceding three years having indicated that the use of calcium arsenate promised to become a practical means of control for the blueberry maggot in Washington County, steps were taken in 1928 to test the treatment on a large scale. The topography of much of the land comprising the large areas devoted to the industry, and the comparatively short time during which the dust can be successfully applied, suggested the feasibility of using the airplane as a rapid and effective means of applying the calcium arsenate.

During the summer of 1928, blueberry land was again dusted experimentally with calcium arsenate on a fairly large scale by means of an orchard duster mounted on a heavy farm wagon, and an airplane was also employed to apply the dust to slightly more than 1,000 acres of land.[5] In addition to this experimental work, two of the blueberry growers undertook dusting as a practical proposition during the season of 1928, and treated several hundred acres by means of horse-drawn power outfits. Altogether, this work has afforded considerable opportunity for observing the efficiency of the airplane as compared with the ground machine for dusting blueberry land. The results of this comparative study made during the season of 1928 are presented in this circular.

## PERSONNEL AND EQUIPMENT

A biplane (fig. 1, A) powered with a 160-horsepower engine was used for the application of the calcium arsenate. The plane was fitted with a galvanized-iron hopper placed in the passenger cockpit. The dust dropped from the hopper into a large venturi tube on the bottom of the machine, whence it was blown by the propeller blast. The agitator was a hand-operated device which proved inadequate for starting the dust and for maintaining a uniform flow. The dust was discharged through an opening extending entirely across the bottom of the hopper. This opening was approximately 24 inches long and had a maximum vertical height of about 6 inches. The cut-off, consisting of a metal slide that closed the opening, gave constant trouble by allowing the dust to leak more or less when the device was closed and by jamming when open.

Because of the rough nature of the landing field, the plane had difficulty in taking off with much more than 175 pounds of dust in the hopper. This lack of capacity greatly reduced the efficiency of the plane as a dusting machine.

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[5] Two blueberry growers furnished the calcium arsenate; all other expense involved in the airplane work was borne by the Bureau of Entomology.

The airplane required for its operation a pilot and a mechanic. During the dusting operations, the Bureau of Entomology furnished two other men to weigh the dust and to load it aboard the plane, and one man was present on each plot to make observations at the time of application.

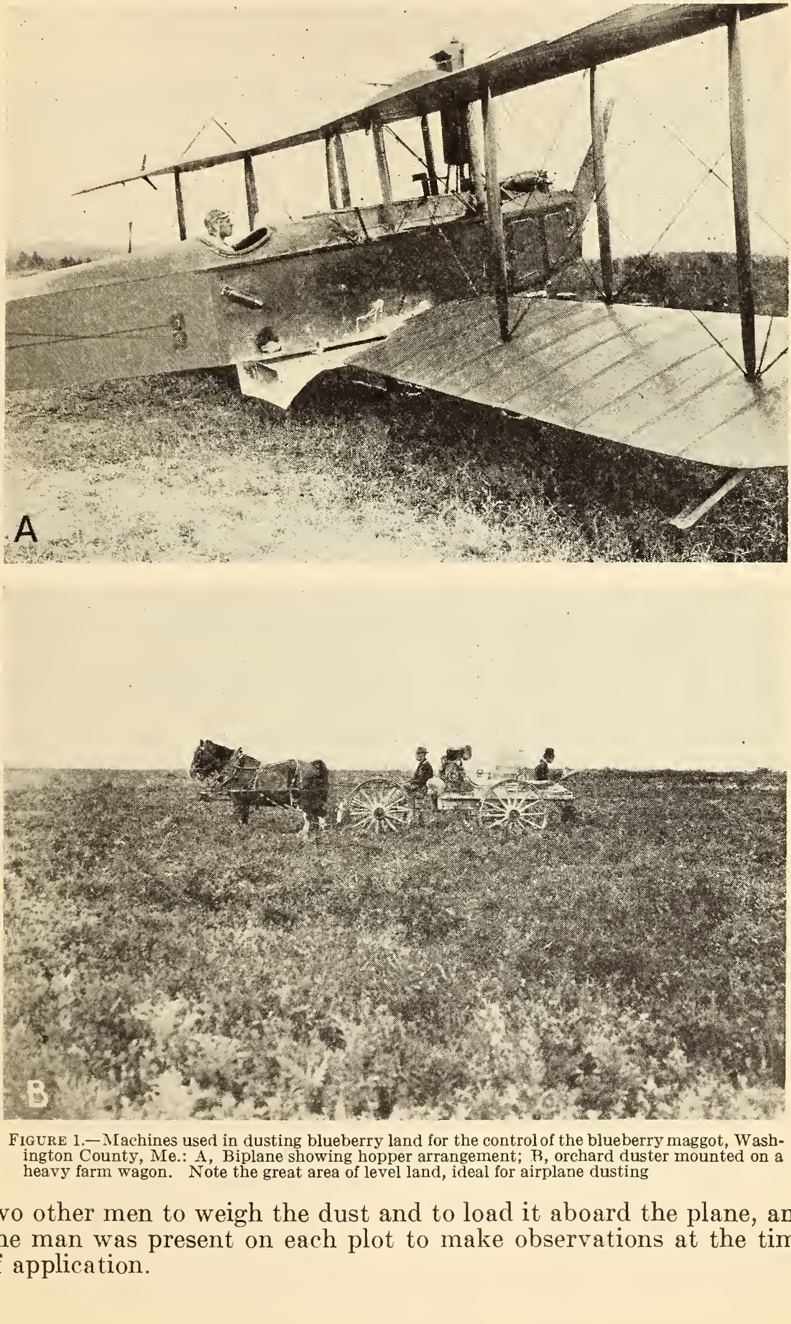

Figure 1.—Machines used in dusting blueberry land for the control of the blueberry maggot, Washington County, Me.: A, Biplane showing hopper arrangement; B, orchard duster mounted on a heavy farm wagon. Note the great area of level land, ideal for airplane dusting

The ground machine (fig. 1, B) was an orchard duster, with an 8-horsepower, air-cooled engine, mounted on a heavy farm wagon drawn by two horses. The duster crew consisted of a driver and one man to handle the nozzle. In the experimental work one man was present to observe the work and to indicate the route for the driver.

## RELIEF AND GROUND COVER

The blueberry land of this locality consists of high, level or rolling, plateau land (fig. 1, B), or of moderately sloping to steep, rocky hillsides. In general the surface of the land is very rough and is often studded with huge bowlders.

The blueberry bushes grow from 6 to 12 inches in height. These plants have come in on this wild land entirely by natural dissemination. The land receives no culture other than mowing of the weed bushes and more or less irregular burning-over every third spring. On much of the land even this culture is neglected or carelessly done. As might be expected under such circumstances, the stand of blueberries on the greater part of this land is exceedingly patchy and irregular, rendering difficult any accurate determination of the effectiveness of experimental treatments.

Much of the blueberry land is more or less covered with weed bushes from 1 to 4 or 5 feet high. In general the land is free from trees, but in many places there are scattered trees, both living and dead, which greatly interfere with effective dusting by airplane. (Fig. 2, A.)

The plots selected for experimental work included all the common types of blueberry land of this section.

## SURVEYING AND MARKING THE PLOTS

The plots to be dusted by airplane were surveyed by means of transit and tape, through the cooperation of engineers of the United States Bureau of Public Roads. The plots were outlined by small cheesecloth pennants attached to stakes at 200-foot intervals. Each corner was marked by a large cheesecloth L, each side of which was 10 feet long and 18 inches wide. The middle of each plot was marked by an X of similar size. The rough and bushy nature of much of the land necessitated this distinct marking in order that the pilot could quickly determine the outlines of the plot.

The experimental plots for the horse-drawn machine were marked off by stakes placed in rows 100 feet apart. These stakes indicated the duster routes and also the points for taking samples at picking time.

The plots were limited in shape and size by relief, soil conditions, and other factors which restricted the stand of blueberries or the productiveness of the crop.

In laying out the areas to be dusted by airplane an attempt was made to include all of the blueberries in the block without taking in too much nonbearing land. This led to some irregularity in the otherwise rectangular shape of the plots. The largest available blocks of suitable blueberry land were selected for the airplane plots. The smallest of these was 35.81 acres, and the largest was 102.84 acres; the average area was 58.04 acres. A complete list of all of the experimental plots, with the area of each, is given in Tables 4 and 5. For airplane work it would be more economical to have larger areas than the plots used in this work. In many cases the plots selected consisted of hill land, the size of which was definitely limited by topography. There are thousands of acres of level blueberry land on the barrens of Washington County, but under the present cultural conditions it is exceptional to find solid blocks of much more than 100 acres that could be dusted at a profit. It is probable that in the future there will be a tendency for the growers to throw larger areas into solid blocks of well-tended blueberry land. In laying out the plots for the ground machine, it was not necessary to have such large areas and more attention was paid to suitability for experimental work than to size. In the summer of 1928 the ground-machine plots ranged in size from 8.03 to 15.95 acres, with an average of 11.91 acres.

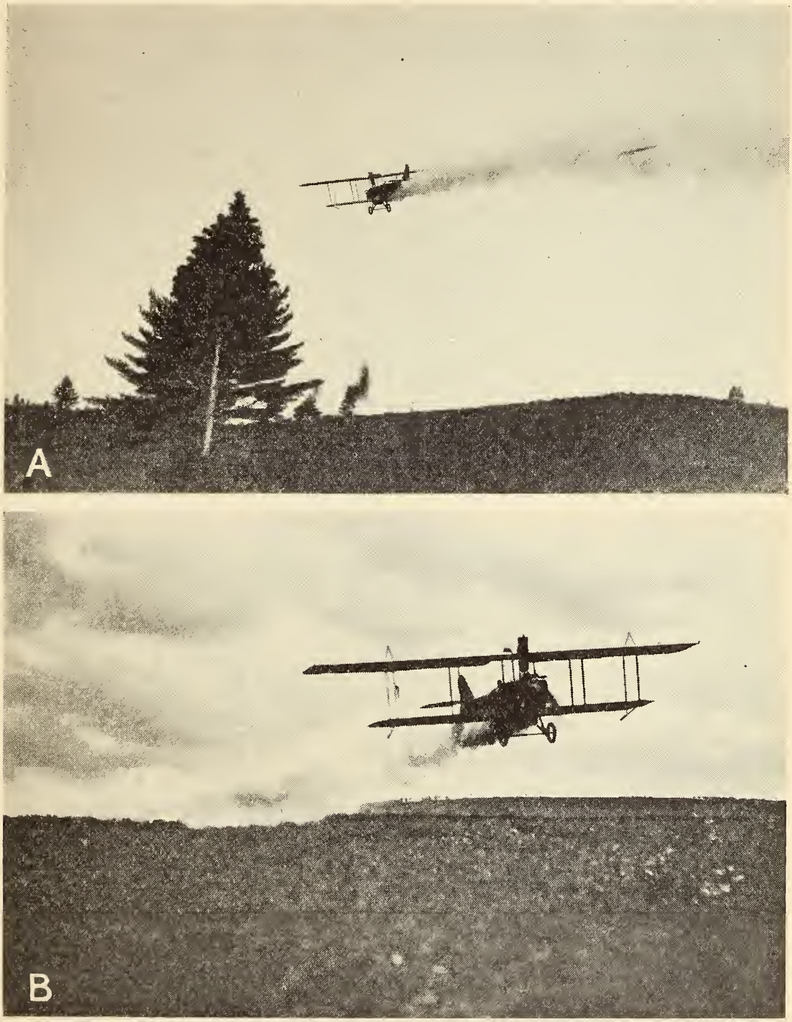

Figure 2.—Airplane dusting of blueberry land for the control of the blueberry maggot, Washington County, Me.: A, Plane forced by trees to fly too high for effective dusting; B, plane flying low over level land and distributing an effective dust cloud

## TIME OF DUSTING AND ATMOSPHERIC CONDITIONS

For best results in dusting, the atmosphere should be quiet and the plants should be covered with dew. The most favorable time was usually in the early morning, from just as soon as it was light enough to see (about 3 o'clock) until too much breeze arose (usually about 8 o'clock). The atmosphere was seldom quiet enough for satisfactory dusting in the afternoon. During the course of this work dust was applied at times ranging from 3 a. m. until noon, and from 5 until 7.30 p. m., and under a great variety of atmospheric conditions.

On clear mornings it usually became light enough for the airplane to operate by 3.30 a. m., but there was nearly always fog present until much later. This delayed the operation of the plane, and it frequently happened that what were otherwise the most favorable conditions had passed before the plane could be used.

During July the climate of eastern Maine is characterized by frequent fog, mist, and showers. A record of the rainfall following the dusting period of 1928 is given in Table 1. Dusting operations were frequently hampered by rain and excessive wind.

TABLE 1.—*Rainfall records for five days following each application of calcium arsenate for the control of the blueberry maggot, Cherryfield, Me., 1928*

| Plot No. | First application | | | Second application | | |
|---|---|---|---|---|---|---|
| | Date of dusting | Rains within 5 days after application | Total precipitation | Date of dusting | Rains within 5 days after application | Total precipitation |
| | | *Number* | *Inches* | | *Number* | *Inch* |
| 1 A[1] | July 17 | 2 | 0.08 | July 30 | 1 | 0.06 |
| 2 A | July 18 | 3 | 1.21 | July 29 | 1 | .33 |
| 3 A | do | 3 | 1.21 | July 28 | 2 | .43 |
| 5 A | July 21 | 3 | 1.48 | | | |
| 8 A | do | 3 | 1.48 | | | |
| 11 A | July 27 | 2 | .43 | | | |
| 1 G[1] | July 16 | 2 | .08 | July 31 | 1 | .06 |
| 2 G | July 18 | 3 | 1.21 | July 29 | 1 | .33 |
| 3 G | July 19 | 2 | 1.18 | Aug. 3 | 3 | .44 |
| 4 G | July 22 | 3 | 1.48 | | | |
| 5 G | July 27 | 2 | .43 | | | |

[1] Series A, airplane plots; series G, ground-machine plots.

## METHODS OF APPLICATION

The plane was loaded with a determined quantity of dust, and the pilot distributed this as uniformly as possible over the area to be dusted. It was always necessary for the plane to make two or more trips to a plot, as it was never possible to carry in one load sufficient dust to treat an entire plot. On each trip it was necessary for the pilot to know what proportion of the total dust he carried, and with this load he treated a corresponding portion of the plot. In applying the dust, the plane flew from 15 to 40 feet above the ground, or even higher in a few cases, depending upon the contour of the land and the number of trees present. On large level areas free from obstructions the plane flew close to the ground (fig. 2, B) and crossed back and forth over the area at more or less regular intervals. Where the land was hilly (fig. 3, A) the plane followed the contour of the land to a considerable extent. Where trees were present on the land it was necessary to pick a course between the trees or to fly over them. (Fig. 2, A.)

The observer stationed on each airplane plot at the time of application was furnished with a red flag and a white flag. The white flag signaled the pilot to dust. The display of the red flag indicated that atmospheric conditions were unfavorable, and the work was discontinued.

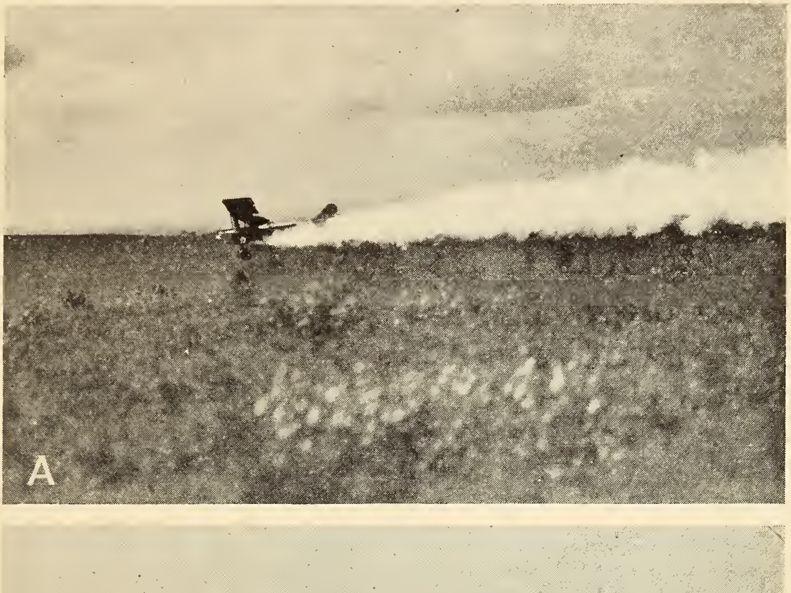

FIGURE 3.—A, Airplane flying parallel to the edge of a plateau, showing the behavior of the dust cloud as it is discharged from the plane; B, dusting blueberry land by means of a horse-drawn power duster

In making applications with the horse-drawn duster, the machine was drawn back and forth across the plot in lanes approximately

100 feet apart. The nozzle of the machine, pointing to the rear and held slightly upward, was kept swinging from side to side, thereby dusting a strip 100 feet wide. (Fig. 3, B.) The use of the horse-drawn machine was at first subject to serious criticism because of the probable destruction of berries by the feet of the horses and by the wagon wheels in passing over the land. Careful observation has shown, however, that the quantity of berries destroyed in this way is so small as to be negligible.

## DISTRIBUTION OF THE DUST

Preliminary tests with the airplane indicated that by flying at a height of 25 feet, at a speed of 60 miles per hour, with a calm atmosphere, and discharging dust at the rate of 6.5 pounds per acre, the dust covered a strip 150 feet wide on level land. The behavior of the dust cloud varied so much under the prevailing conditions of atmosphere and topography that it was almost never possible to lay down a series of uniform clouds of dust at regular intervals across the land. Proper distribution of the dust required considerable observation and judgment on the part of the pilot.

In general, the distribution of dust from the airplane was excellent on level land when the application was made during calm atmospheric conditions with the plane flying 20 or 25 feet above ground. (Fig. 2, B.) When it was necessary for the plane to fly at a height of 35 or 40 feet to avoid trees (fig. 2, A) the distribution was usually not satisfactory.

On large areas of level land a light breeze of 4 to 6 miles per hour was not objectionable, and at times it was beneficial by breaking up local convection currents and air strata.

The distribution of dust on hilly land presents a difficult problem for the airplane. In a calm atmosphere the dust cloud tends to flow downward into the valleys, resulting in an application that is excessive on the lower land and insufficient on the higher portions. A breeze of 3 to 5 miles per hour often facilitates dusting the windward side of a hill, but renders it difficult, if not impossible, to make a satisfactory application on the leeward slope. Careful study and attention on the part of the pilot in placing the dust clouds in advantageous positions can do much to improve the applications on hillsides.

The behavior of the dust cloud evidently depends upon a number of factors, including wind, local convection currents, humidity, temperature of both air and soil, barometric pressure, topography, and height of the plane above ground. At times the dust cloud behaved in a peculiar manner. On one occasion a level tract was dusted late in the afternoon. The atmosphere was almost perfectly motionless. The plane flew from 15 to 30 feet above the ground. On one part of this tract the dust settled perfectly, but over about one-third of the area the dust hung in a definite stratum about 15 feet above the ground and finally drifted to another part of the plot before it settled.

In places where the plane flew too close to the ground, and excessive quantities of dust were dumped suddenly from the hopper, the plants received far too much poison. This, however, did not happen frequently.

When applications are made by means of the ground machine, it is desirable to have a very calm atmosphere. When the air movement becomes strong enough to cause much more than a slight rustling of the leaves of birch bushes growing on the land (about 3 or 4 miles per hour), conditions are unsatisfactory for effective dusting.

It is difficult to regulate the feed mechanism of the ground machine so as to throw out the dust at the rate desired, and the natural tendency of most operators is to apply an excessive quantity of dust. Irregularities in the distribution of dust from the ground machine resulted from variations in the speed or occasional stopping of the team, from changes in air movement, and from pointing the nozzle downward at too direct an angle. The application of dust by the ground machine was more "patchy" than by airplane, the irregularities involving areas seldom more than a few feet square. On carefully dusted areas this "patchiness" probably did not lessen the effectiveness of the application. The irregularities of airplane applications, however, involved larger areas, often as much as several acres, and this undoubtedly resulted in failure to secure control where large skips occurred.

## TIMING THE APPLICATIONS

In applying the calcium arsenate, the immediate object is, of course, to destroy the adult flies before they deposit eggs in the berries. Careful studies indicate that the month of July is the normal period of emergence of the flies. By applying the dust during the latter half of July, the berries were protected during the important egg-laying period, and maximum results were obtained with a minimum number of applications. The schedule can be arranged so that the last application is made at least two weeks before the fruit is harvested, thus minimizing the danger of arsenical residue on the berries at picking time.

## RESULTS OF THE DUSTING

The results were carefully determined in 1928 on 6 plots dusted by airplane, 3 receiving two applications and 3 receiving one application of calcium arsenate. These plots were selected for checking purposes because of comparatively favorable conditions which they offered for determining results, and because of a satisfactory range of conditions of relief. Of the plots dusted by ground machine, 3 received two applications and 2 received one application.

The method of sampling used was to collect a sample of approximately 500 berries from each of 20 points uniformly distributed over the plot. The berries were collected by means of a rake—the customary method of picking blueberries in this locality. For each sample, from 6 to 10 sweeps of the rake were made within an area approximately 50 feet square. Care was exercised to avoid taking too many berries in one sweep, and to distribute the sampling well over the 50-foot square. Experience rendered it possible to collect such a sample with a total slightly in excess of 500 berries. In the laboratory, five 100-berry samples were counted from each of these 20 field samples; making a total of 100 samples, each containing 100 berries. One such series of samples was taken on a treated plot and a like series on the check plot. No sample was taken, either in the treated plot or in the check plot, nearer than 200 feet from the margin of the area dusted by airplane, or nearer than 100 feet from the margin of the area dusted by ground machine.

The berry samples were subjected to a boiling and washing process,[6] which is not described in detail here but which permits an accurate determination of the number of maggots present in the berries.

Tables 2 and 3 show the effect of the dusting on these plots. The import of the data may be illustrated by the following comparisons:

TABLE 2.—*Results of applications of calcium arsenate by airplane for the control of the blueberry maggot, Cherryfield, Me., 1928*

| Plot No. | Applications | Dates of applications | Maggots per 100 berries | | Reduction in number of maggots |
|---|---|---|---|---|---|
| | | | Check plot | Dusted plot | |
| | *Number* | | *Number* | *Number* | *Per cent* |
| 1 A | 2 | July 17 and 30 | 7.47±0.43 | 1.57±0.21 | 78.98±3.06 |
| 2 A | 2 | July 18 and 29 | 4.64± .30 | .36± .06 | 92.24±1.39 |
| 3 A | 2 | July 18 and 28 | 2.96± .21 | .67± .06 | 77.36±2.58 |
| Average | | | | | 82.86±2.45 |
| 5 A | 1 | July 21 | .95±0.08 | 1.17± .10 | −23.16±14.79 |
| 8 A | 1 | do | 3.18± .26 | 3.10± .27 | 2.52±11.65 |
| 11 A | 1 | July 27 | 2.14± .15 | 1.10± .10 | 48.60±5.94 |
| Average | | | | | 9.32±11.40 |

TABLE 3.—*Results of applications of calcium arsenate by ground machine for the control of the blueberry maggot, Cherryfield, Me., 1928*

| Plot No. | Applications | Dates of applications | Maggots per 100 berries | | Reduction in number of maggots |
|---|---|---|---|---|---|
| | | | Check plot | Dusted plot | |
| | *Number* | | *Number* | *Number* | *Per cent* |
| 1 G | 2 | July 16 and 31 | 3.81±0.23 | 0.38±0.05 | 90.03±1.44 |
| 2 G | 2 | July 18 and 29 | 4.64± .30 | .27± .05 | 94.18±1.14 |
| 3 G | 2 | July 18 and Aug. 3 | 2.93± .23 | .47± .06 | 83.96±2.39 |
| Average | | | | | 89.39±1.02 |
| 4 G | 1 | July 22 | 6.84± .45 | 1.11± .10 | 83.77±1.81 |
| 5 G | 1 | July 27 | 12.76± .53 | 7.45± .47 | 41.61±4.41 |
| Average | | | | | 62.69±3.37 |

Two applications of dust by airplane gave an average reduction in the number of maggots of 82.86 per cent, a minimum reduction of 77.36 per cent, and a maximum reduction of 92.24 per cent.

Two applications of dust by ground machine gave an average reduction of 89.39 per cent, a minimum reduction of 83.96 per cent, and a maximum reduction of 94.18 per cent.

Only two plots were tested with one application by ground machine. One of these showed a reduction of 41.61 per cent and the other a reduction of 83.77 per cent in the number of maggots. The average reduction for these two plots was 62.69 per cent.

A single application by airplane yielded less satisfactory results. Of the three plots on which results were determined, only one (11 A) showed a significant reduction in the number of maggots per 100 berries. On one plot (5 A) there was an excess of 23.16 per cent of maggots on the dusted plot as compared to the untreated area. The high probable error, which is due, no doubt, to the low initial infestation, indicates that this result is not significant.

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[6] This is a modification of a process developed by B. J. Howard of the Bureau of Chemistry and Soils.

These data indicate that in general the treatments applied by means of the ground machine were somewhat more effective than were the treatments made by airplane. This may be due in part to the fact that larger quantities of dust per acre were inadvertently applied by the ground machine. Probably the most important reason for the comparative inefficiency of the airplane treatments is the fact that, except under the most favorable conditions, a considerable proportion of the dust distributed by the airplane failed to reach the land for which it was intended.

When the dust is applied under favorable conditions, it appears that treatment by airplane should be as effective as when the application is made by ground machine. That this is actually true is indicated by plots 2 A and 2 G, which were dusted by airplane and ground machine, respectively. These two plots were located within a few hundred feet of each other, and a single check area served for both plots. The land was level, free from trees, and in every respect was favorable for airplane work. The treatments by airplane and by ground machine were applied on the same mornings, July 18 and 29, each plot receiving two applications. Although the application of dust to the ground-machine plot was considerably heavier than that made by the airplane, the percentage reduction of maggots is not materially different on the two plots, 92.24 per cent reduction on the airplane plot and 94.18 per cent reduction on the ground-machine plot.

The results were further compared by the analysis of variance[7] in nearly similar plots treated by airplane and ground machine, respectively. No significant differences were found. That is, when the 200 samples (Table 2, plots 2 A and 3 A) obtained from the airplane plots are compared with the 200 samples (Table 3, plots 2 G and 3 G) obtained from the ground-machine plots, the 400 samples appear to be homogeneous.

## COMPARATIVE COST OF TREATMENT

The record of materials used and flying time involved in the airplane work during the summer of 1928 are shown in Table 4, and the record of labor and materials for the ground-machine experiments for the summers of 1927 and 1928 are shown in Tables 5 and 6. These tables are interesting, but, because there are so many factors involved which are not included in the tables, the data here presented do not give a satisfactory basis for estimating the total cost of dusting. For example, the time required to haul the machine to the land to be dusted is often more than the time consumed in making the application. This is especially true of small areas.

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[7] FISHER, R. A. STATISTICAL METHODS FOR RESEARCH WORKERS. Ch. 7, illus. London. 1925.

TABLE 4.—*Record of flying time and calcium arsenate used in airplane dusting for the control of the blueberry maggot, Washington County, Me., 1928*

| Plot No. | Area of plot | Applications | Total area dusted | Approximate distance from landing field to plot | Trips | Estimated flying time to and from plots | Flying time consumed in applying dust | Total flying time | Dust carried each trip | Total dust applied [1] |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Acres* | *Number* | *Acres* | *Miles* | *Number* | *Minutes* | *Minutes* | *Minutes* | *Pounds* | *Pounds* |
| 1 A | 43.16 | 2 | 86.32 | 4 | 4 | 34 | 19 | 53 | 145 | 580 |
| 2 A | 102.84 | 2 | 205.68 | 9 | 8 | 160 | 42 | 202 | 170 | 1,360 |
| 3 A | 70.72 | 2 | 141.44 | 4 | 8 | 150 | 29 | 179 | 116 | 928 |
| 4 A | 41.32 | 2 | 82.64 | 2 | 4 | 16 | 18 | 34 | 140 | 560 |
| 5 A | 78.05 | 1 | 78.05 | 1½ | 3 | 26 | 14 | 40 | 170 | 510 |
| 6 A | 52.34 | 1 | 52.34 | 8 | 2 | 40 | 15 | 55 | 170 | 340 |
| 7 A | 68.87 | 1 | 68.87 | 8 | 2 | 40 | 9 | 49 | 224 | 448 |
| 8 A | 74.38 | 1 | 74.38 | 5 | 2 | 32 | 9 | 41 | 170 | [2] 340 |
| 9 A | 36.73 | 1 | 36.73 | 5 | 2 | 32 | 8 | 40 | 120 | 240 |
| 10 A | 40.40 | 1 | 40.40 | 8 | 2 | 40 | 14 | 54 | 135 | 270 |
| 11 A | 67.95 | 1 | 67.95 | 7 | 3 | 54 | 17 | 71 | 150 | 450 |
| 12 A | 35.81 | 1 | 35.81 | 1¼ | 2 | 12 | 13 | 25 | 120 | 240 |
| 13 A | 45.91 | 1 | 45.91 | ½ | 2 | 12 | 13 | 25 | 150 | 300 |
| Total | 754.48 | | 1,016.52 | | | 648 | 220 | 868 | | 6,566 |

[1] An attempt was made to apply 6.5 pounds of dust per acre. In most cases slight excess was added to allow for wastage.

[2] By mistake plot 8 A received only 4.57 pounds of dust per acre. The average for all other plots was 6.61 pounds per acre.

TABLE 5.—*Record of time and calcium arsenate used in ground-machine dusting for control of the blueberry maggot, Washington County, Me., 1928*

| Plot No. | Area of plot | Applications | Total area dusted | Time consumed in application | | Quantity of dust per acre | |
|---|---|---|---|---|---|---|---|
| | | | | First application | Second application | First application | Second application |
| | *Acres* | *Number* | *Acres* | *Minutes* | *Minutes* | *Pounds* | *Pounds* |
| 1 G | 15.95 | 2 | 31.90 | 35 | 45 | 8.40 | 6.08 |
| 2 G | 10.33 | 2 | 20.66 | 25 | 35 | 7.16 | 11.62 |
| 3 G | 13.77 | 2 | 27.54 | 53 | 40 | 4.65 | 8.86 |
| 4 G | 11.48 | 1 | 11.48 | 60 | | 7.40 | |
| 5 G | 8.03 | 1 | 8.03 | 28 | | 8.34 | |
| Total | 59.56 | | 99.61 | 201 | 120 | | |

TABLE 6.—*Summary of records of labor and materials required in dusting blueberry land with a ground machine, Cherryfield, Me., 1927 and 1928*

| Year | Total area dusted | Quantity of dust per acre | Machine and team labor per acre | Man labor per acre |
|---|---|---|---|---|
| | *Acres* | *Pounds* | *Minutes* | *Minutes* |
| 1927 | 116.56 | 6.10 | 3.48 | 10.44 |
| 1928 | 99.61 | 7.66 | 3.22 | 9.66 |

The growers who undertook dusting as a practical proposition during the season of 1928, using horse-drawn power dusters, estimate that they can make the application at a cost not exceeding $1 per acre per application, including every expense except the cost of the calcium arsenate. During this same period the cost of application by airplane was far in excess of this figure. It is to be expected that such experimental work would be expensive, and that the cost per acre of applications by airplane would be very greatly reduced after the work is well organized on a commercial basis. Even taking this into consideration, however, it seems improbable that airplane dusting could be organized on a sufficiently large scale in Washington County, in the immediate future, to compete in price with dusting by ground machine.

## RECOMMENDATIONS FOR THE CONTROL OF THE BLUEBERRY MAGGOT

The results of the work outlined in the foregoing discussion, substantiating as they do the results obtained during the two preceding seasons, enable the writers to recommend with some confidence the application of calcium arsenate for the control of the blueberry maggot in eastern Maine. There are several points yet to be determined, and the study is being continued. Tentative recommendations may be summarized briefly as follows:

### MATERIAL TO USE

The calcium arsenate used in this work is the standard insecticide dust, exactly the same as the material used extensively for combating the cotton-boll weevil and certain other insect pests. Detailed specifications are as follows: It should contain not less than 40 per cent total arsenic pentoxide ($As_2O_5$) and not more than 0.75 per cent of water-soluble arsenic; and it should have a density of not less than 80 or more than 100 cubic inches per pound.

### QUANTITY OF DUST TO USE

The calcium arsenate should be applied as nearly as possible at the rate of 6 to 7 pounds per acre. Much less than 6 pounds per acre is likely to be ineffective, whereas much more than 7 pounds increases the danger of injury to the blueberry plants. Great care should be used to distribute the dust as uniformly as possible over the area being treated, otherwise serious burning of the blueberry plants may result where excessive quantities of the dust are applied.

### NUMBER OF APPLICATIONS

On land which produces a sufficient quantity of berries to justify the expense, it is advisable to make two applications of calcium arsenate. On poorer land one application may be advisable. In any case it seems that under ordinary circumstances it is advisable to apply calcium arsenate only to land producing berries with a maggot infestation above the tolerance for canned fruit. It is not profitable to apply dust to well-burned land during a summer following burning, since no fruit is produced during such a season and the destruction of the flies will have no effect upon the maggot infestation during the next summer. It is desirable to dust as large areas as possible, as this reduces the danger from flies drifting in from unpoisoned areas and tends to reduce the cost of operation. As far as practicable, no unpoisoned blueberries should be left around the borders of the dusted areas.

### DATES OF APPLICATION

On land receiving two applications, the first should be made during the period from July 13 to 20. The second application should be made from 7 to 10 days after the first. All applications should be completed before August 1.

Land that is to be dusted only once should receive an application during the period of July 18 to 24.

The above dates apply to the Cherryfield-Columbia Falls section of Washington County, Me., in normal seasons. The writers' studies over a period of three years tend to indicate that there is not much seasonal variation for these dates. There is considerable variation, however, in the advance of the season in different sections of eastern Maine, and the proper dates for dust applications should be determined for each section where it is necessary to combat the maggot.

In abnormally early or late seasons, probably the best plan is to begin the first application of dust as soon as the very first newly hatched maggots appear in the ripening blueberries. This can be determined only by a very careful examination of a large number of samples of blueberries, starting soon after they begin to ripen, and continuing daily until maggots are found.

### ARSENICAL RESIDUE AT PICKING TIME

A careful study is being made of the quantity of arsenic remaining on the fruit at picking time. Present information indicates that if applications are properly made not later than two weeks before picking, using the recommended quantity of dust, and followed by normal rainfall, the quantity of arsenic remaining on the fruit at picking time is negligible. In very dry seasons the dust will not be washed off so thoroughly. Great care should be exercised to avoid the application of excessive quantities of dust to the blueberry plants. In any case where there may be doubt about the residue being sufficiently low, the berries should be given a light washing in the factory before canning.

### SUMMARY

Experiments made in 1927 and 1928 showed that calcium arsenate applied as a dust is effective in controlling the blueberry maggot.

Large areas of blueberry land in Washington County, Me., have a topography nearly ideal for airplane dusting. However, it is difficult to find solid blocks of as much as 100 acres suitable for profitable dusting.

Under favorable conditions, dusting by airplane was as effective as dusting by ground machine, but under usual conditions of atmosphere and topography the ground machine gave somewhat better results than did the airplane.

Dusting hill land presented a difficult problem for the airplane. Heavy fog during the early morning hours greatly reduced the length of time available for satisfactory dusting by airplane, as compared with the time available for dusting with ground machine. It is doubtful if the increased rapidity of the work of the plane compensated for this shortening of the dusting time.

The results of the experiments warrant the making of tentative recommendations for the control of the blueberry maggot.

## ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

**July 29, 1930**

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